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Selected US specifications from IPC sub-class
E21B

(54) Controlling artificial lift in wells

(57) Crude oil production from a well is stimulated by artificial lift. To control the artificial lift and hence the production of oil, a choke unit 112 associated with a natural flow production well is modified so that the artificial lift fluid is passed through the choke 212 itself and the crude oil is passed around but not through the choke.

The choke unit may be modified by inserting a spool 209 below the choke itself, the spool defining passages which lead the artificial lift fluid into the choke and the oil to bypass the choke. The spool may also have a port 210 in the crude oil passage for the injection of chemical fluid.

Fig.1A.

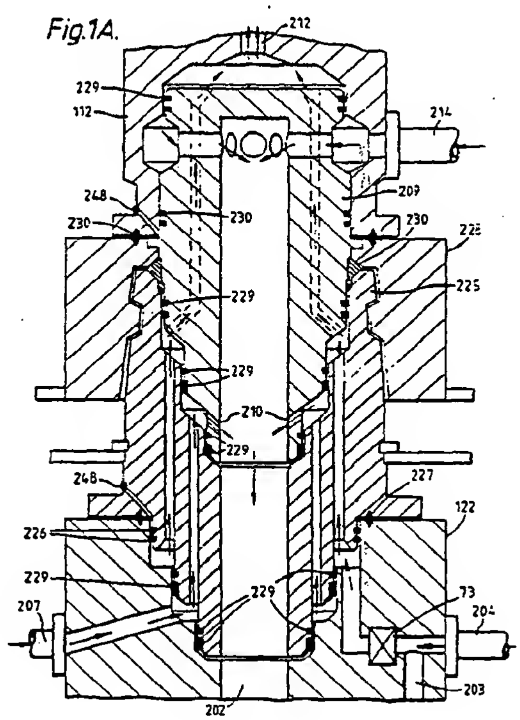

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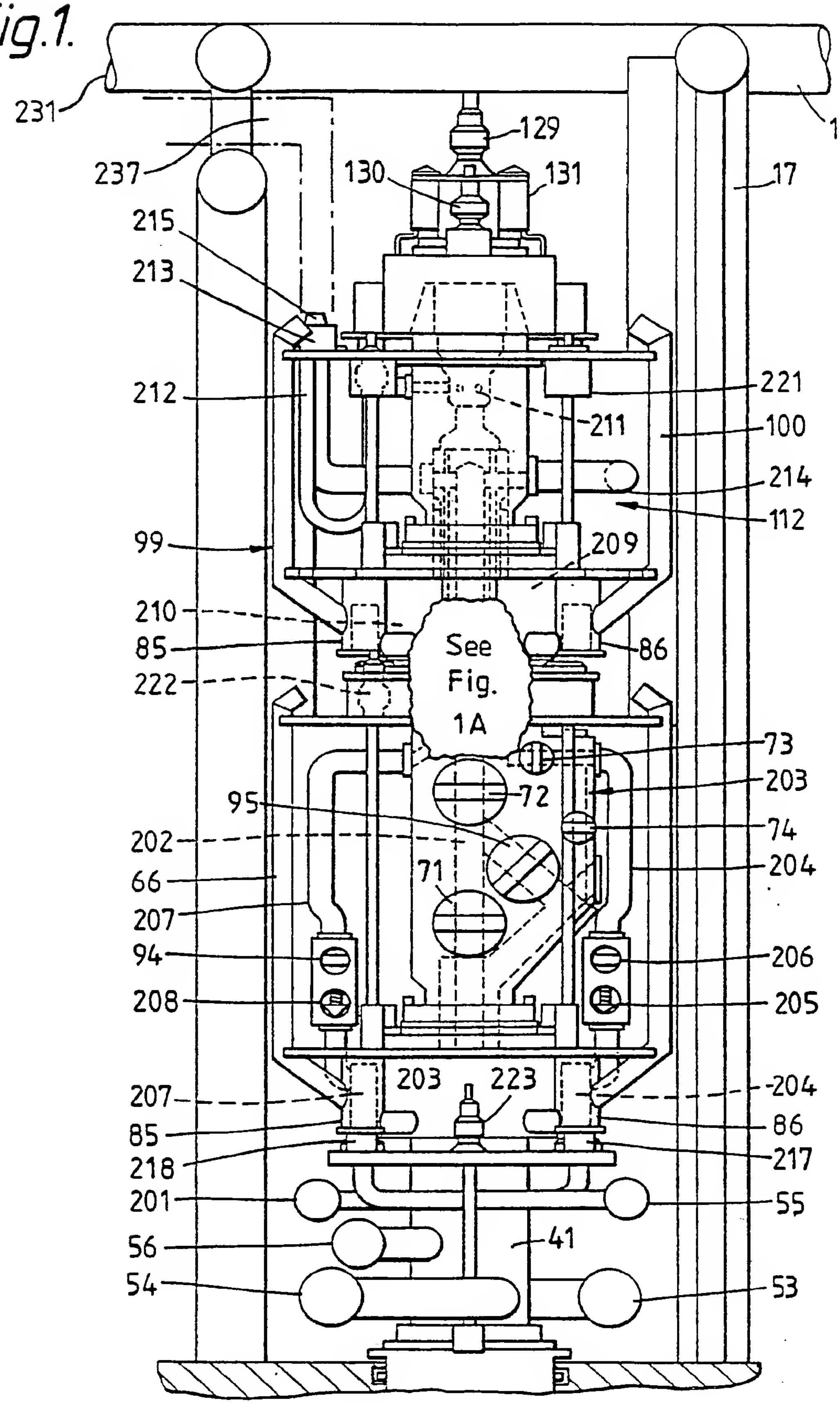
Fig.1.



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See Fig. 1A
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Fig.1A.

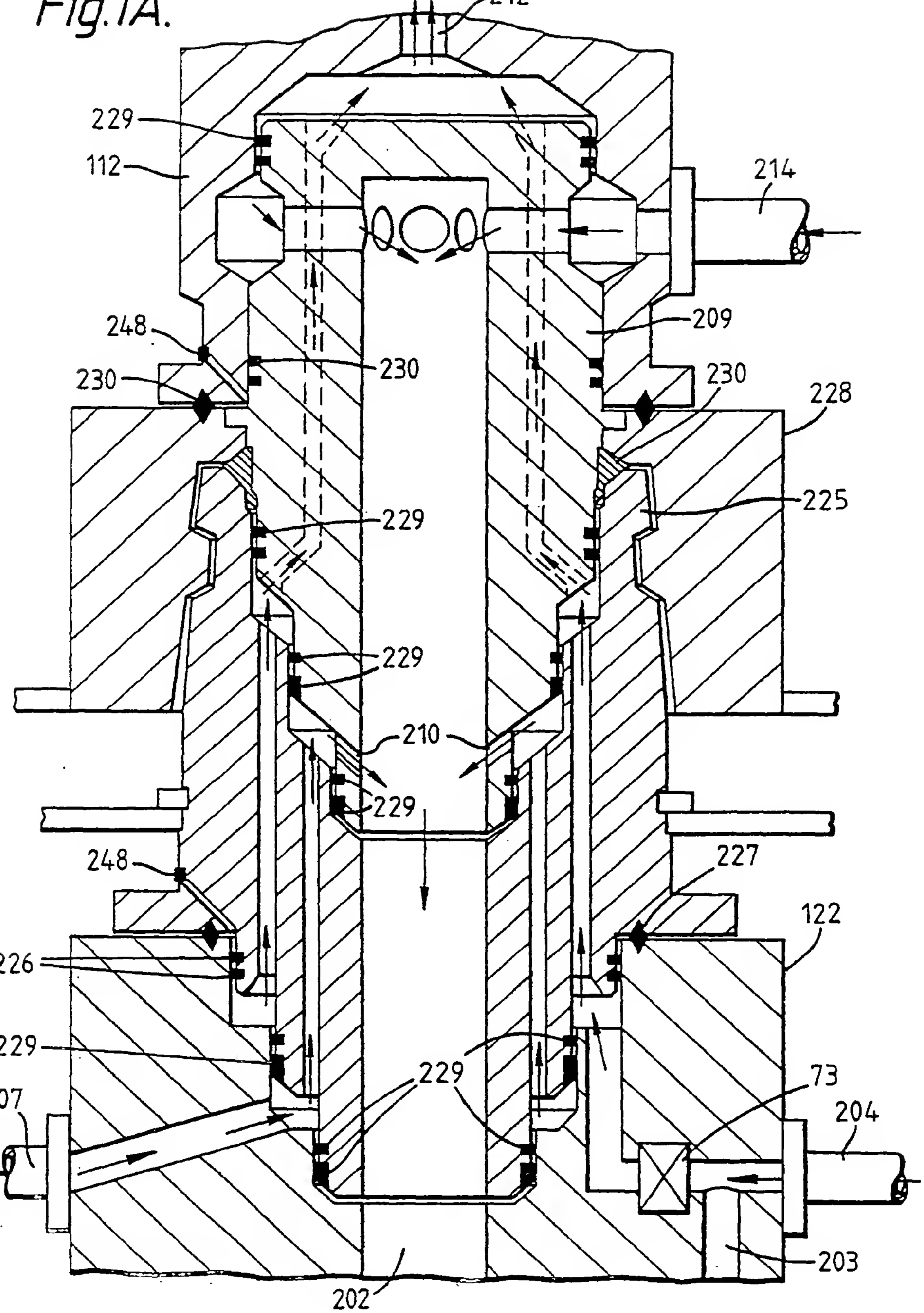
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Fig. 2.

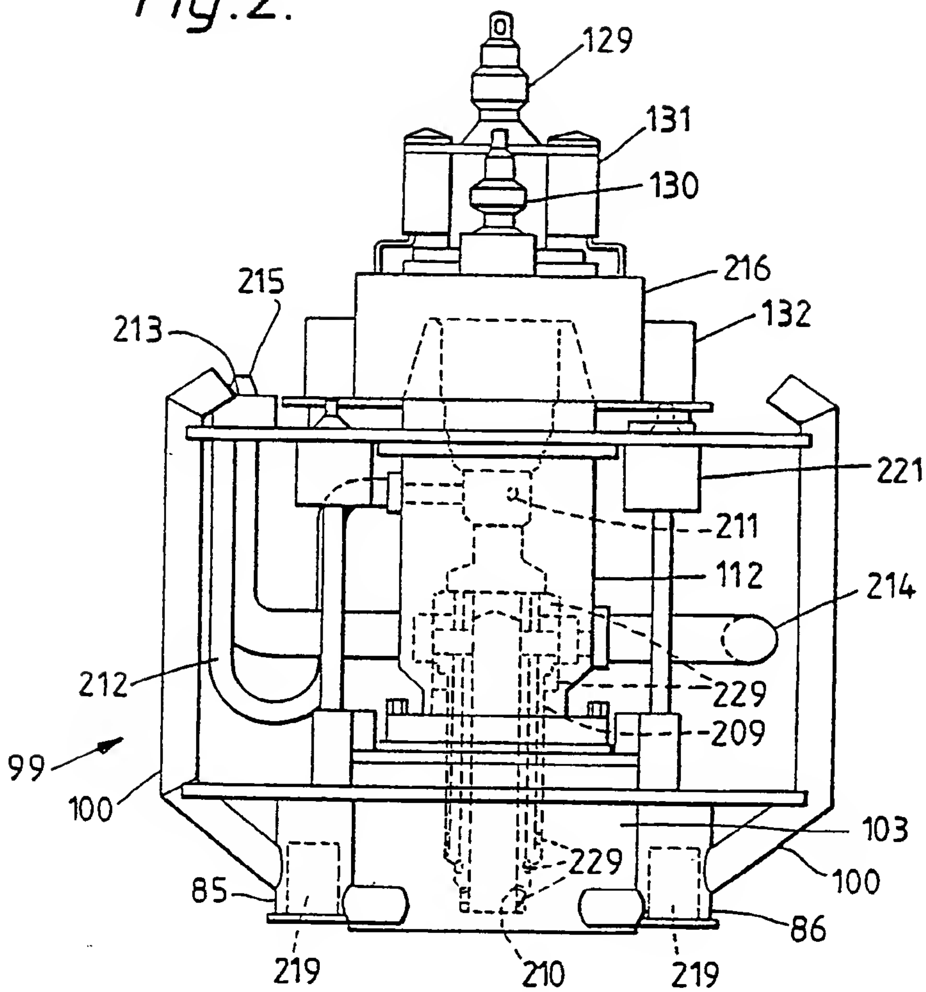
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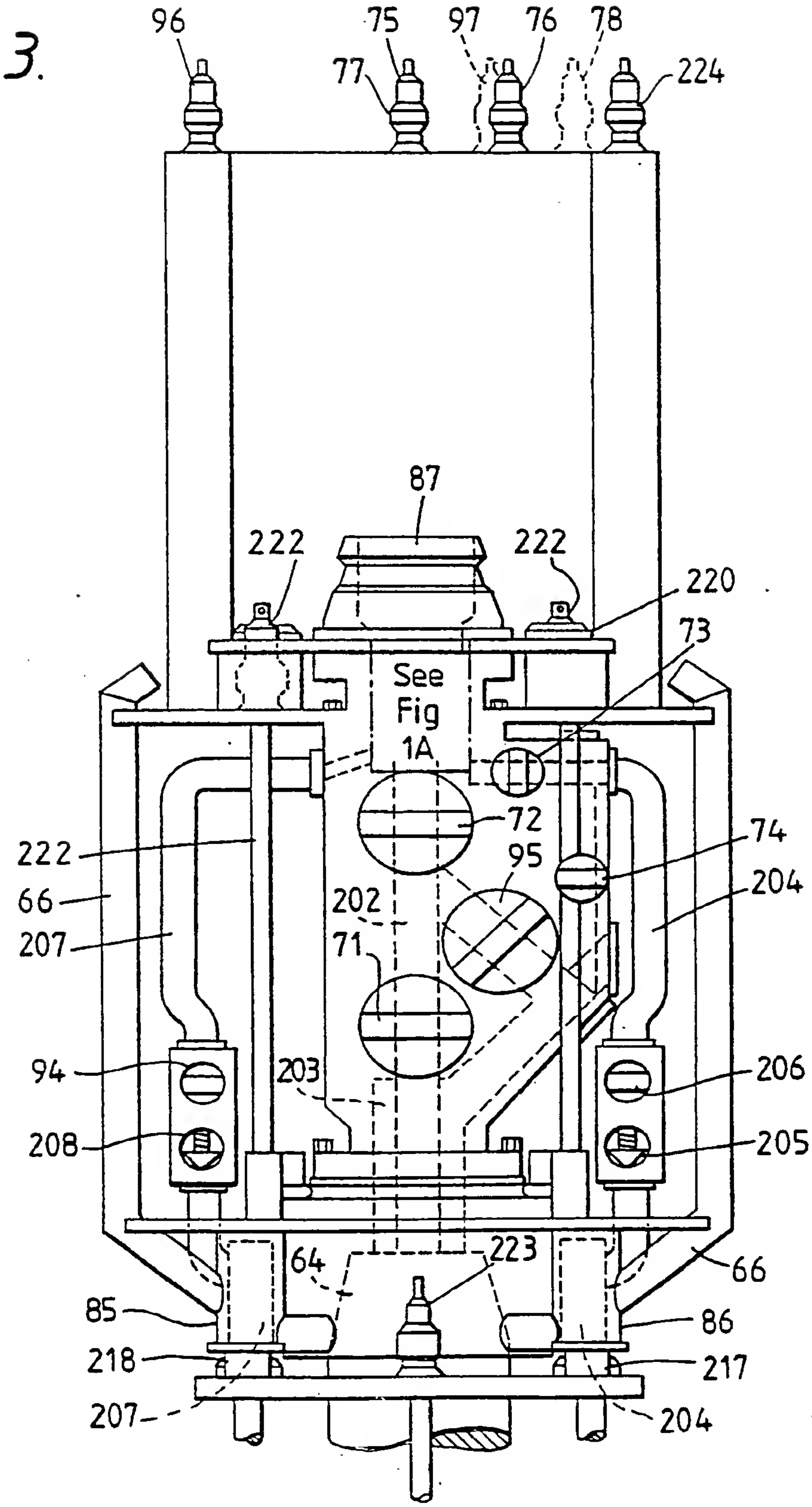
Fig.3.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See Fig 1A
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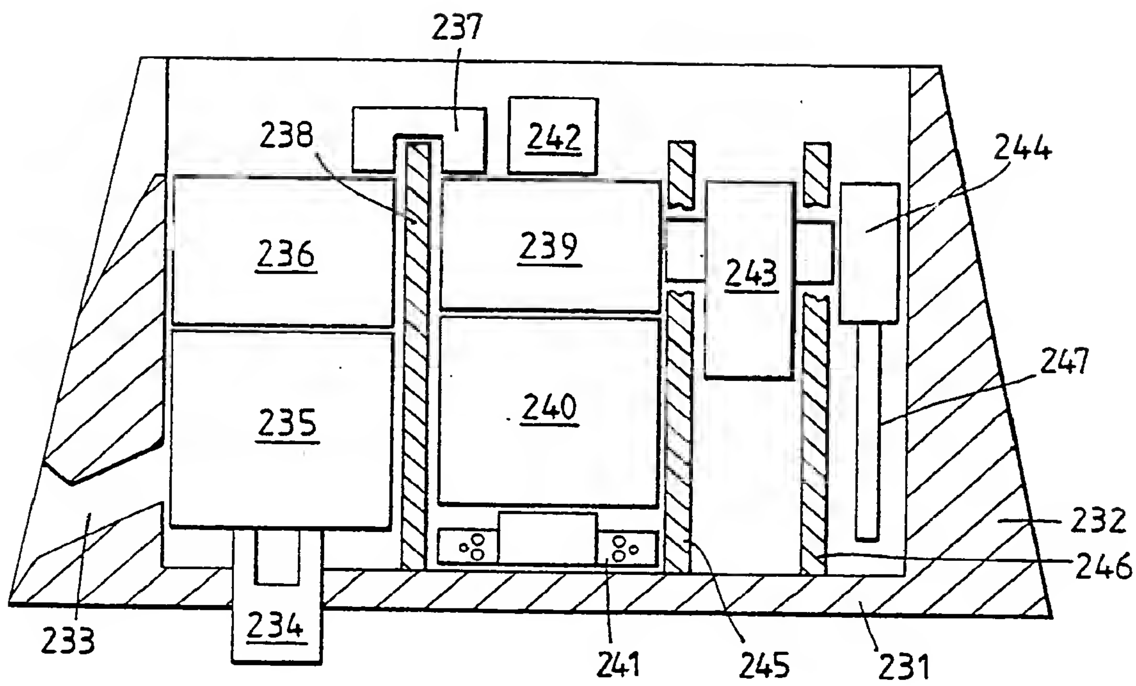
Fig.4.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STIMULATING OIL PRODUCTION

This invention relates to a method of stimulating oil production from an oil well and, particularly, to a modified choke for use with the method.

With many oil wells, the pressure in the oil reservoir is sufficient to lift the oil up the well to the surface. This pressure can, and usually is, sustained by injecting water into the water layer below the oil layer and/or by injecting gas into the gas layer above the oil layer. Sometimes, however, this so-called "secondary recovery" is inadequate or becomes inadequate and further assistance is needed to stimulate production.

One such further method of stimulation is "artifical lift". Within this term, as defined in this present application, is included:

(i) injection of a fluid lighter than the crude oil into the crude oil column of the well. This lighter fluid may be gas (e.g. a hydrocarbon gas such as methane, ethane or propane, or a gas inert to crude oil such as nitrogen) or a liquid e.g. a light fraction of crude oil. The density of the crude oil column is thereby lowered and flow of crude oil up the well stimulated.

(ii) pumping of the crude oil using a down-hole jet pump or a down-hole turbine-driven pump. The fluid used to drive the pump in this embodiment may be gas or liquid of any density. It may be "dead" crude oil (i.e. produced crude oil from which any dissolved gases have been removed). However, with such pumping it is not really practicable to recover and recycle the

fluid used; the fluid has to be exhausted from the turbine into the crude oil column. The fluid used thus has to be compatible with the crude oil and is recovered with the crude oil.

With either form of artificial lift it will be appreciated that the amount of crude oil produced will be proportional to the amount of fluid used for the lift and that it will be necessary to regulate the amount of fluid for optimum, economic oil production.

If the oil well is on land it is not too difficult to provide an artificial lift fluid and to control the injection. If the oil well is an underwater well it is, again, not too difficult to provide and control artificial lift if the well is associated with a fixed or floating oil production platform. There can be individual lines running to each well and the control of the artificial lift fluid injection can be effected on the platform.

The most difficult situation occurs with underwater wells, which, either because of the water depth or for other reasons, have no associated above water production equipment. With these wells, the well heads and all the associated control equipment are on the sea floor including chokes for regulating the crude oil flow.

It is not practicable to control artificial lift fluid injection from the water surface in such a situation, particularly if there are a number of associated underwater wells. Individual lines to each well would give an excessive and impractical number of lines. The only feasible solution would be to have a common artificial fluid lift line and to control the injection into each well using the available subsea control mechanism on each individual well head.

The present invention is based on the realisation that, with artificial lift, control of crude flow can be regulated by passing the artificial lift fluid input through the choke rather than by passing the crude oil output through the choke.

According to the present invention therefore, a method of controlling artificial lift applied to an oil well comprises passing the fluid used for artificial lift through the well choke and passing the crude oil produced around but not through the choke.

According to another aspect of the present invention, a choke suitable for controlling an oil well to which artificial lift is applied comprises a choke unit housing a choke, a passage for artificial lift fluid into the unit, through the choke, and out of the unit and a passage for crude oil into and out of the unit not passing through the choke itself.

The method and choke of the present invention may be used from the start of the production of oil from a well, if such a well needs artificial lift from the start. However, as previously explained, oil production by artificial lift may be the last phase of the life of an oil well after primary and secondary recovery techniques have become inadequate. A particular feature of the choke of the present invention is that it can be produced by a simple modification of a normal type of choke. Thus, a normal choke unit designed to control crude oil output from a well can be adapted for use in the present invention by providing a spool within it, this spool defining passages for both artificial lift fluid and for crude oil, the passage for artificial lift fluid passing into, through and out of the choke itself, and the passage for crude oil passing, into, through and out of the spool without passing through the choke itself.

The spool may be a cylinder within the choke unit below the choke itself adapted to connect with a crude oil outlet line and an artificial lift fluid inlet line in a manifold block, the passages defined by the cylinder for the artificial lift fluid and the crude oil being concentric.

The choke may be in a manifold block of a standard type for feeding the crude oil output of a well into a crude oil collection system, but it may also need some modification to include, within it, a passage with control valves for the artificial lift fluid. The present invention includes, in combination, a modified choke unit for controlling artificial lift fluid as described above with a modified manifold block for the admission of artificial lift fluid into the choke unit.

It may be desirable to inject chemical fluid into the crude oil

output from any well, whether producing normally or with the assistance of artificial lift. The chemical fluid could, possibly, be included in the artificial lift fluid but, alternatively, or in addition, the spool used in the present invention may have a port or ports in the crude oil passage for the injection of chemical fluid, and the manifold block may have a suitable passage with one or more control valves for feeding chemical fluid to the choke unit and particularly to the ports in the spool.

The method of artifical lift control and the modified choke unit of the present invention may be used with oil wells in any location. Thus it may, if desired, be used with an oil well on land, or an underwater well controlled from a fixed or floating platform. For reasons explained earlier, it is, however, particularly suitable for use with underwater wells controlled by a subsea production system, where the difficulties of control are most acute. Such subsea oil production systems normally have a template fixed to the sea bed within the confines of which are positioned all the normal units of an oil production system e.g. well heads, tree blocks, manifold blocks, chokes etc.

If there are a number of associated well heads in the sub-sea production system, a single artificial lift fluid line may be used to bring the artificial lift fluid to the template, the fluid being then fed to individual well heads and controlled by the present invention.

The present invention while suitable for use with any subsea oil production system is particularly suitable for use with the subsea oil production system described and claimed in published UK Patent Specification No 2174442. This subsea oil production system has a template with a three-dimensional framework enclosing a well head and tree module above a well slot, a manifold selector head and manifold module above a manifold slot, and a production bridge (formed of an upper tree block and an upper manifold block) linking the tree and manifold modules. A choke is positioned on top of the upper manifold block, and the oil flow within the system is through the well head, tree module and upper tree block, across the

production bridge into the choke and then down through the upper manifold block, manifold module and manifold selector head. The production bridge may carry interchangeable pipes for bringing crude oil across from the well side to the manifold side of the system and for carrying fluid (e.g. injection water) in the other direction from the manifold side to the well side.

Artificial lift fluid from a common line to the template, and also chemical fluid, if desired, supplied by another common line, can be fed into the manifold module through self-sealing pressure balanced couplings on either side of the manifold selector head. Suitable couplings are described in UK Patent Application No 8722007. It can be controlled by via a control system (e.g. through the control tray of a control system as described in UK Patent Application No 8717462.

In the specific description of the subsea oil production system of UK Patent Specification No. 2174442 (e.g. Figure 12) the production bridge is shown as a pre-assembled unit which is run and landed as a whole. However, to enable the sub-sea production system to be serviced by a mono-hull dynamically-positioned vessel it is preferable that the production bridge is run and landed as two independent modules (i.e. upper tree block and an upper manifold block) which are joined by a saddle (e.g. the saddle described in UK Patent Application No. 8707303.

UK Patent Application No. 8707307 describes another sea bed process complex having an insert choke in a module above anupper manifold module with this module connected to a well tree module by a saddle.

The choke of the present invention for stimulating oil production may be used with either of the above sub-sea oil production systems or with any other oil production system. It will now be specifically described with reference to

Figure 1 which is a view of the manifold side of a sub-sea oil production system based on Figure 14 of UK Patent Specification No. 2174422 but modified to have a saddle linking the manifold module to a well tree module and to have artificial lift and

chemical fluid injection facilities.

Figure 1A which is a section through the manifold hub marked "see Figure 1A" in Figure 1,

Figure 2 which is a slightly enlarged view of the upper manifold module and choke unit of Figure 1, and

Figure 3 which is a slightly enlarged view of the manifold module unit of Figure 1, and

Figure 4 which is a diagramatic representation of another oil production system having a choke of the present invention.

Figure 1 is based on the right hand manifold side of Figure 14 of UK Patent Specification No. 2174442 modified for artificial lift and, for convenience, the parts of Figure 1, 2 and 3 of the present invention which are identical with those of Figure 14 will be given the same numbers as those of Figure 14.

In Figure 1, at the base of the column is the manifold selector head body 41. This has a crude oil outlet port 53, a water injection inlet port 54, a test fluid outlet port 56 (which can also be used as a kill port for a well), a chemical fluid inlet port 55 and, in addition, an artificial lift fluid inlet port 201. Ports 53, 54 and 56 can serve the same function as in Figure 14 and connect via internal lines (not shown) with corresponding lines and valves in the manifold module. The chemical fluid inlet port 55 and the artificial lift fluid inlet port 201, however, connect with the manifold module through self-sealing pressure balanced couplings 218 and 217 mounted in a datum plate around the manifold selector head.

Thus crude oil outlet port 53 connects via an internal line with crude oil production line 202 in the manifold module. This line 202 has in it upper and lower compact production master valves 71 and 72. Surrounding oil production line 202 is a concentric line 203 which branches off through upper and lower annulus isolation and operation valves 73 and 74. Cross over valve 95 connects the production and concentric lines 202 and 203. It is normally kept shut but can be used to switch flows from the production side to the annulus side or vice versa. In the operation of an oil production system using a choke of the present invention,

the crossover valve 95 will not normally be used but concentric line 203 may be used to provide kill fluid for the well, this fluid being supplied into line 203 via test fluid port 56.

The manifold module has thus been modified as compared with the module of Figure 14 of UK Patent Specification No. 2174442. In the case of a well which requires artificial lift from the start the modified module can be run and landed initially. In the case of a well which requires artificial lift after a period of normal production, the original manifold module may be retrieved and a modified module substituted.

The artificial lift fluid comes in from the artificial fluid port 201 of the manifold selector head through coupling 217 and line 204 into the manifold module passing through a lift check valve 205 and a lift control valve 206 to link with the annulus line on the inlet side of upper annulus isolation valve 73.

Also within the manifold module is a chemical fluid injection line 207 which is supplied from chemical fluid injection port 55 of the manifold selector head through coupling 218. In this line 207 is a chemical fluid check valve 208 and a chemical fluid control valve 94. Valves 71, 72, 73, 74, 94, 95 and 260 have ROV mechanical overrides.

The oil production line 202, the artificial lift fluid line 204 and the chemical fluid line 207 converge at the top of the manifold module into passages leading up through a connector hub into a connector of an upper manifold block 99. This is shown in detail in Figure 1A. In Figure 1A connector hub 225 fits into manifold module 122 with seals 226 and a metal gasket 227 to make it liquid and gas tight. Also shown in the manifold module 122 are the oil production line 202, the pipe leading to the annulus line 203, the artificial lift fluid line 204 with its isolation valve 73 and the chemical fluid injection line 207.

Surrounding connector hub 225 is connector 228 of an upper manifold block 99. This block houses the choke main body 112 having within it choke spool 209.

There are seals 229 and gaskets 230 at all points where liquid

tight joints are required between the connector hub 225, the connector 228, the choke main body 112 and the choke spool 209. The top seals 229 are elastomeric rings fitting in grooves, the lower seals 229 are slip-on metal-to-metal seals. Monitoring and test points 248 and also shown. It will be noted that the subsea connection interfaces have double sealing compressive metal gaskets and lateral elastomeric seals with the monitoring and test port facilities 248 between them.

As shown in Figure 1A the connector hub 225, and choke spool define two sets of ported concentric passages.

The oil production line 202 is the innermost passage, surrounded by annular chemical fluid passage 207, which, in its turn, is surrounded by annular artificial lift fluid passage 204. Within spool 209 chemical fluid passage 207 connects through ports 210 with oil production line 202 thereby merging the two lines so that chemical fluid mingles with the oil. The annular artificial lift fluid line 204 remains a separate line within the spool, however, leading up into the choke insert 211 (Figure 1). Choke insert 211 is the choke proper of the choke unit so that it is the artificial lift fluid which is controlled by the choke. The line exits from the choke insert 211 into pipe 212 which can be connected by a coupling 213 (Figure 1) to a saddle which takes the fluid across to the annulus pipe of an upper tree block.

The oil production line 202 within spool 209 connects with a production flow loop line 214 (i.e. it does not pass through the choke insert 211 and is thus not controlled by the choke). Line 214 also has a coupling 215 (Figure 1) so that it can be connected by a saddle to the production pipe of an upper tree block.

The flows of artificial lift fluid, production oil and chemical injection fluid are indicated by arrows in Figure 1A.

The production and annulus pipes extend across the saddle into the upper tree block and would normally run down through production and annulus lines and valves in the tree module and well head (similar to the lines in the upper manifold block, manifold module and manifold selection head) into the production and annulus bores

of the well itself. However, to achieve artificial lift the artificial lift fluid in the annulus line must be diverted at some point on the well side of the production system.

If the artificial lift fluid is a gas or low density liquid used to lower the density of the oil column in the well, then the fluid can be injected into the oil column in known manner through gas lift valves fitted into the production completion string.

If the artificial lift fluid is a liquid used to drive a downhole jet pump or turbine pump, it can again be fed to the pump in known manner. Such pumps and their placement in a well are well known in the industry. The liquid after driving the turbine is exhausted from the turbine into the oil column in the well.

From Figures 1, 1A, 2 and 3 it will be seen that artificial lift fluid can be fed into and through choke insert 211 and can thus be controlled by the choke to regulate the artificial lift system. The crude oil output, which would normally have gone through choke insert 211, is diverted by the spool to flow into the oil production outlet line without any choke control.

If an oil well needs artificial lift from the beginning of its life a modified choke unit with spool may be fitted initially in the subsea production system. More usually, however, artificial lift is only resorted to towards the end of the life of a well when normal oil recovery under reservoir pressure, assisted if necessary by water and/or gas injection, has declined. The normal choke then has to be replaced by a modified choke with spool. The use of chokes which can be removed from and replaced into a subsea oil production system without disturbing the main production units, is a feature of a number of subsea production systems, and it is a particular feature of the subsea production system of UK Patent Specification No. 2174442. As previously explained this subsea production system is of modular design with all modules capable of being remotely aligned with and guided into the template framework. All modules are locked to adjoining modules with remotely releasable connections.

Figure 4 shows, diagrammatically, another modular design for a

sub-sea production system in which a modified choke of the present invention may be used. It comprises a template 231 with protective side walls 232 and a passage 233 through one of the walls for lines to be brought into or taken from the template, which may be the template of a satellite well.

A well is drilled through the template, so that the template sits over a well head 234. Within the template, above the well head, is a lower tree block 235 and an upper tree block 236. A saddle 237 brings pipes across a dividing partition 238 of the template into a choke module 239 placed above a manifold module 240 and busbar 241 (which has pipework to carry production oil). Insert choke 242 on top of the choke module can be a choke designed for artificial lift according to the present invention.

The remainder of the oil production system is a control system having a control pod 243 and control tray 244 separated by template partitions 245 and 246. An umbilical 247 brings hydraulic and/or electrical power into the control tray.

The systems shown in Figures 1, 1A, 2 and 3 and in Figure 4 have their chokes at the top of manifold modules. It is thus relatively easy to remove and replace the choke (e.g. to substitute a choke of the present invention for a more conventional choke).

Provided the manifold module and other modules, as initially installed, have been designed with the requisite artificial lift valves, lines, and controls, no other parts need be changed.

Figures 1, 2 and 3 of this present specification show, in addition to the artificial lift fluid supply system, a number of features of the modular sub-sea oil production system, which are used to guide, align, lock and control the individual modules. These features are not essential features of the present invention but, for completeness, they are described briefly below using where appropriate the same reference numerals as used in Figure 14 of UK Patent Specification No. 2174442.

The framework of a three dimensional template is shown at 16 and 17. The manifold module and the upper manifold block fit within this framework being lowered into it and being guided and aligned

during lowering by a framework of chamfered corner posts 66 of the manifold module and a similar framework of chamfered corner posts 100 of the upper manifold block. There are self-aligning two-step soft landing jacks 85, 86 on the upper manifold block and on the manifold module.

Choke connector 216 (Figure 2) is separate from the upper manifold block 99 and is capable of separate placement and removal. It also, therefore, has soft landing jacks 132.

All modules are designed to be releasably connected with the various fluid lines passing through releasable connectors at the module junctions. Thus the artificial lift fluid line 204 and the chemical fluid line 207 have self-sealing couplings 217, 218 at the junction of the manifold selector head and the manifold module. The production and annulus lines pass from the manifold selector head to the manifold module through a lockable connector 64 and the production and annulus lines pass from the top of the manifold module into the upper manifold block and the choke main body through a hub 87 on the manifold module locking with a manifold connector 103 in the upper manifold block.

All connections between modules are designed to be locked and released hydraulically. Similarly all compact valves in the modules are designed to be actuated hydraulically. To that end there are hydraulic couplings at each junction i.e. couplings 131 at the top of the choke connector and couplings 219 at the base of the upper manifold block linking with couplings 220 at the top of the manifold module. These hydraulic couplings may supply high and/or low pressure hydraulic fluid to actuate connectors and valves. There may also be associated electrical couplings for electrical input into and to transmit electrical signals from monitoring instruments in the subsea production system.

Finally, although all connections and valves are designed to be operated hydraulically, they all have mechanical overrides so that they can be operated mechanically by a remotely operated vehicle (ROV) in the event of hydraulic failure. Thus, associated with each valve and connecting latch is a rod with a spigot at the end, with

the spigots positioned so that they are accessible to a ROV. The rods and spigots shown in Figures 1 to 3 are choke spigot 129 for controlling the choke insert, choke connector spigot 130 for operating the choke connector coupling, manifold connector spigots and rods 221 for the upper manifold block connector couplings, manifold module spigots and rods 222 for the manifold module connector couplings, and spigot and rod 223 for the manifold selector head connector coupling.

Rods for mechanical operation of the valves extend up from the manifold module to spigots (Figure 3). From left to right in Figure 3 they are mechanical override spigots (with valve position indicators) for the chemical fluid injection valve 96, the upper and lower production valves 75, 77, the crossover valve 97, the upper and lower annulus valves 76, 78 and the artificial lift fluid valve 224.

Claims:

1. A method of controlling artificial lift applied to an oil well comprising passing the fluid used for artificial lift through the well choke and passing the crude oil produced around but not through the choke.

2. A choke unit suitable for controlling an oil well to which artificial lift is applied comprising a choke unit housing a choke, a passage for artificial lift fluid into the unit, through the choke, and out of the unit and a passage for crude oil into and out of the unit not passing through the choke itself.

3. A choke unit as claimed in claim 2 having within it a spool, said spool defining passages for both artificial lift fluid and for crude oil, the passage for artificial lift fluid passing into, through and out of the choke itself, and the passage for crude oil passing, into, through and out of the spool without passing through the choke itself.

4. A choke unit as claimed in claim 3 wherein the spool is a cylinder within the choke unit below the choke itself adapted to connect with a crude oil outlet line and an artificial lift fluid inlet line in a manifold block, the passages defined by the cylinder for the artificial lift fluid and the crude oil being concentric.

5. A choke as claimed in claims 2, 3 or 4 wherein the passage for crude oil has a port or ports for the injection of chemical fluid into the crude oil.

6. A sub-sea oil production system comprising, in combination, a choke unit for controlling artificial lift fluid as claimed in any

of claims 2 to 5 and a manifold block having a passage with one or more control valves for the admission of artificial lift fluid into the choke unit.

7. A sub-sea oil production system as claimed in claim 6, wherein the manifold block also has a passage with one or more control valves for feeding chemical fluid to the choke unit.

8. A sub-sea oil production system according to claim 1 as hereinbefore described with reference to the accompanying drawings.